

# **Determination of the impact of certain exhaust controls devices possibly used in retrofitting diesel powered vehicles or machinery.**

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Looking at the situation known by me on this **17<sup>th</sup> of June 2004**, I can make the following analysis of this situation and suggest some ways to improve this analysis.

## **What we know today:**

NO<sub>2</sub> is regulated on the working place (in Germany and Switzerland the thresholds are 6 mg/m<sup>3</sup>) at a level which is 6 times lower than CO (threshold of 35 mg/m<sup>3</sup>), which indicates that NO<sub>2</sub> has serious toxic features. But for a reason unknown yet CO is a regulated emission of engines while NO<sub>2</sub> is not.

Certain devices containing precious metals have the consequence to transform a significant portion of emitted NO to NO<sub>2</sub>, some of them deliberately in order to regenerate a DPF. According to EMPA (National Lab of Switzerland) the absolute emissions of NO<sub>2</sub> by such devices installed on a bus can reach 300 to 400 ppm at low load low speed when a non catalyzed device would emit less than 40 ppm.

In a totally different study, a French laboratory, testing a light duty engine equipped with a DOC, has established that in certain driving conditions NO<sub>2</sub> emissions can reach 260. The purpose of this study was not to check the highest possible level and we can not say that this value is a real worst case.

## **The situation today and its possible extrapolation**

It is a political decision, especially in California, to lower the particulates emissions by all possible tools including DOCs and CSF,

- what could be the consequence of the widespread of DOCs and CSFs?
- is it necessary to define a ceiling to the emissions of NO<sub>2</sub> by retrofit devices?
- on a longer term, is it necessary to introduce a NO<sub>2</sub> limit in emissions of new vehicles?

It seems that it is the ambition of ARB staff to answer to these questions and of IDRAC to make recommendations on the 2 first ones.

## **How to approach these questions?**

Everything depends indeed of the correct evaluation of the actual exposure risks associated with different vehicles equipped with different devices. This exposure risk must be fairly assessed in real conditions of operations and of exposure.

It is why it is important to start with monitoring these exposures risks, before defining the driving cycle on which the emissions have to be checked.

Exposure risks are quite easy to establish in confined atmospheres (tunnels, mines, ...) a lot more difficult in open air.

The amount of equipped vehicles is rather low and we can not expect a real impact on the air quality at large, even in a canyon street.

There are a large variety of devices and it is difficult to determine the contribution of each of them in a classical air quality monitoring (stationary station).

## **Suggestions to run a campaign of measurements, giving the maximum of useful information.**

### **Case 1: school buses**

These types of vehicles are of special interest as they carry kids during a quite long time per day and they can contribute to the exposure of kids to NO<sub>2</sub> through different scenarios:

- if the bus follows another vehicles equipped with a system emitting a high level of NO<sub>2</sub> (we know that cabins of vehicles are places where the emissions of the traffic accumulate when the vehicle is forced to follow a polluting vehicle in a traffic line)
- when stopping to allow kids to get in or out, the pollution of the cabin can be the consequence of the emissions of the bus itself
- the kids waiting around or passing behind the bus can be exposed to high levels of emissions, especially when the exhaust control devices produce high levels of NO<sub>2</sub> at low speed and idle

### **Option 1**

What I propose is the following:

- equip a bus with a set of analysis tools (\*) to measure different pollutants. I prefer a bus to any other vehicle as it would be possible to measure the pollutions at various positions in the cabin and determine if there are places which are more exposed. Let's call this bus "KoB" (for Kids on Bus)
- have KoB following (\*\*) a reference bus with absolutely no equipment and burning ordinary fuel; lets call it "EB" for Emitting Bus
- have KoB following (\*\*) EB equipped with a commercial DOC, having the same engine
- have KoB following (\*\*) EB equipped with a CSF (there could be 2 buses if ARB wants to investigate the differences of emissions between a coated filter and a CRT). It is also important to have the same engine as on reference EB.

#### **(\*) Analysis tools:**

There is an interesting debate between two basic approaches: limiting the study to gaseous emissions or also include PM monitoring.

Scientifically I would certainly support the idea of a full investigation including PM, but it could be quite costly in time and money, as a good investigation of the PM emissions will necessitate to establish the contribution of different sources: ambient air indeed but also PM which were deposited on the ground and are airborne again due to traffic on the highway, PM generated by tires and road attrition, by brakes, by moving parts on the vehicles. David Kittelson can give good appreciation of the complexity of this type of monitoring of PM.

To be efficient in the shortest delay, I would recommend concentrating on gaseous emissions and assuming ambient air analysis as a blank.

NO<sub>2</sub> is suspected to be created by the vehicle which is followed (EB); in California the risk to have this measure “polluted” by a diesel car equipped with an oxidation catalyst is really negligible.

**(\*\*) “Following”:**

I use this word instead of chase, to avoid any misunderstanding with persons who are not familiar with chase studies.

The purpose is to estimate the distortions in exhaust analysis brought by the exhaust control devices installed on EBs. It is then important to follow EBs at the shortest possible distance, especially in low speed driving conditions the distance between EB and KoB must be the shortest one allowed by safety.

It will be important to register vehicle speed, engine speed and load of KoB in line with measuring gaseous emissions, in order to know in which conditions the highest concentrations of NO<sub>2</sub> are measured. Indeed these parameters would not be exactly the same as the ones of EB, but reasonably similar, taking in account the incertitude due to this type of study. It is then important that all EBs and the KoB have the same engine.

## **Option 2**

If “following” procedure seems too complicated, we can imagine another approach: the Study Bus “SB”.

One bus is selected and equipped with all the necessary measurement tools to measure its own emissions and the concentration of pollutants in the cabin itself. One point in the cabin is sufficient as it will not measure pollution coming from the traffic in front of the vehicle, but only pollution coming from SB exhausts themselves.

SB has first no retrofit equipment, do a complete set of measurements by duplicating the typical itinerary of a school bus in service: stop and go, idling, low speed driving, highway driving, ..., monitoring emissions and vehicle and engine parameters.

SB is then equipped with an exhaust control device (DOC), to proceed to the similar set of measurements following exactly the same itinerary.

SB is then equipped with another exhaust control device (CSF), to proceed to the similar set of measurements following exactly the same itinerary.

## **Discussion**

Option 2 is certainly easier to run than option 1 and require only one bus, but it is not monitoring the risk of exposure, it is only measuring the risk of emitting, giving no insight of the importance of dilution in real atmosphere. In my mind option 2 could be a good tool to identify the highest emissions factors in order to later on duplicate them on bench test.

## **Case 2: working sites**

There is a trend to massively retrofit machineries on construction sites (such Big Dig in Boston) and on harbour docks. Once identified that a site has a large number of retrofitted engines there could be some stationary monitoring stations installed on this site in order to check the level of exposure to NO<sub>2</sub>. These monitoring stations must include at least one close to the highest concentrations of retrofitted engines, at least one far from this concentration and one at 1 or 2 miles not exposed to the winds coming from the site.

## **Discussion**

This will give an overall appreciation and indicate if there is an aggravated risk for the workers and neighbours but do not show what are the most risky technologies.

I do not believe that the intention of ARB is to conclude that PM exhaust control devices are all generating a risk of exposure (if any) to a high level of NO<sub>2</sub>, but rather to create a way in the verification procedure to eliminate those really creating this risk.

## **Conclusion**

There are 2 steps in the approach which was launched by AR staff.

Identification of a risk

Ways to avoid this risk (if any)

Realistic progression is to do a proper identification before entering in discussion about regulating emissions to avoid the risk